HIGH-DENSITY FIBER OPTIC MODULES AND MODULE HOUSINGS AND RELATED EQUIPMENT

High-density fiber optic modules and fiber optic module housings and related equipment are disclosed. In certain embodiments, a front opening of a fiber optic module and/or fiber optic module housing is configured to receive fiber optic components. The width and/or height of the front opening can be provided according to a designed relationship to a width and/or height, respectively, of a front side of a main body of the fiber optic module and/or fiber optic module housing. In this manner, a high density of fiber optic components and/or connections for a given space of the front side of the fiber optic module can be supported by the fiber optic module and/or fiber optic module housing. The fiber optic modules and fiber optic module housings disclosed herein can be disposed in fiber optic equipment including but not limited to a fiber optic chassis and a fiber optic equipment drawer. The modules further comprise at least one module rail disposed on each of the first and second sides of the main body, extending outwardly with respect to the internal chamber of the body. The rails are configured for receipt in a corresponding module guide to facilitate sliding movement of the module.
Description

PRIORITY APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 61/218,870 filed on June 19, 2009.

[0002] This application also claims the benefit of U.S. Patent Application Serial No. 12/771,473 filed on April 30, 2010.

BACKGROUND

Field of the Disclosure

[0003] The technology of the disclosure relates to fiber optic modules and fiber optic module housings provided in fiber optic equipment to support fiber optic connections.

Technical Background

[0004] Benefits of optical fiber include extremely wide bandwidth and low noise operation. Because of these advantages, optical fiber is increasingly being used for a variety of applications, including but not limited to broadband voice, video, and data transmission. Fiber optic networks employing optical fiber are being developed and used to deliver voice, video, and data transmissions to subscribers over both private and public networks. These fiber optic networks often include separated connection points linking optical fibers to provide "live fiber" from one connection point to another connection point. In this regard, fiber optic equipment is located in data distribution centers or central offices to support interconnections.

[0005] The fiber optic equipment is customized based on application need. The fiber optic equipment is typically included in housings that are mounted in equipment racks to optimize use of space. One example of such fiber optic equipment is a fiber optic module. A fiber optic module is designed to provide cable-to-cable fiber optic connections and/or manage the polarity of fiber optic cable connections. A fiber optic module is typically mounted to a chassis or housing which is then mounted inside an equipment rack or cabinet. A technician establishes fiber optic connections to the fiber optic modules mounted in the equipment rack. Due to increasing bandwidth needs and the need to provide a larger number of connections in data centers for increased revenue generating opportunities, a need exists to provide fiber optic modules that can facilitate larger numbers of fiber optic connections in a given space.

SUMMARY OF THE DETAILED DESCRIPTION

[0006] Embodiments disclosed in the detailed description include high-density fiber optic modules and fiber optic module housings and related equipment. In certain embodiments, the fiber optic modules and fiber optic module housings comprise a main body defining an internal chamber disposed between a front side and a rear side. A front opening is disposed along a longitudinal axis in the front side of the main body. A plurality of fiber optic components is disposed through the front opening. In certain embodiments, the width and/or height of the front opening can be provided according to a designed relationship to the width and/or height, respectively, of the front side of the main body to support fiber optic components or connections within the fiber optic module and/or fiber optic module housing. In this manner, fiber optic components can be installed in a given percentage or area of the front side of the fiber optic module to provide a high density of fiber optic connections for a given fiber optic component type(s). In other embodiments, the front opening can be provided to support a designed connection density capacity of fiber optic components or connections for a given width and/or height of the front opening of the fiber optic module and/or fiber optic module housing. The fiber optic components and connections can be provided by fiber optic adapters and/or fiber optic connectors as examples. The fiber optic modules and fiber optic module housings disclosed herein can be disposed in fiber optic equipment including but not limited to a chassis and fiber optic equipment drawer.

[0007] Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description that follows, the claims, as well as the appended drawings.

[0008] It is to be understood that both the foregoing general description and the following detailed description present embodiments, and are intended to provide an overview or framework for understanding the nature and character of the disclosure. The accompanying drawings are included to provide a further understanding, and are incorporated into and constitute a part of this specification. The drawings illustrate various embodiments, and together with the description serve to explain the principles and operation of the concepts disclosed.
BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a front perspective view of an exemplary fiber optic equipment rack with an installed exemplary 1-U size chassis supporting high-density fiber optic modules to provide a given fiber optic connection density and bandwidth capability, according to one embodiment;

FIG. 2 is a rear perspective close-up view of the chassis of FIG. 1 with fiber optic modules installed in fiber optic equipment trays installed in the fiber optic equipment;

FIG. 3 is a front perspective view of one fiber optic equipment tray with installed fiber optic modules configured to be installed in the chassis of FIG. 1;

FIG. 4 is a close-up view of the fiber optic equipment tray of FIG. 3 without fiber optic modules installed;

FIG. 5 is a close-up view of the fiber optic equipment tray of FIG. 3 with fiber optic modules installed;

FIG. 6 is a front perspective view of the fiber optic equipment tray of FIG. 3 without fiber optic modules installed;

FIG. 7 is a front perspective view of fiber optic equipment trays supporting fiber optic modules with one fiber optic equipment tray extended out from the chassis of FIG. 1;

FIGS. 8A and 8B are left perspective views of an exemplary tray guides that can be disposed in the chassis of FIG. 1 and can be configured to receive fiber optic equipment trays of FIG. 6 capable of supporting one or more fiber optic modules;

FIGS. 9A and 9B are perspective and top views, respectively, of an exemplary tray rail disposed on each side of the fiber optic equipment tray of FIG. 3 and configured to be received in the chassis of FIG. 1 by the tray guide of FIG. 8A or 8B;

FIGS. 10A and 10B are front right and left perspective views, respectively, of an exemplary fiber optic module that can be disposed in the fiber optic equipment trays of FIG. 3;

FIG. 11 is a perspective, exploded view of the fiber optic module in FIGS. 10A and 10B;

FIG. 12 is a perspective top view of the fiber optic module of FIG. 11 with the cover removed and showing a fiber optic harness installed therein;

FIG. 12A is a perspective top view of another fiber optic module with the cover removed showing the fiber optic harness installed within guides;

FIG. 13 is a front view of the fiber optic module of FIG. 11 without fiber optic components installed;

FIG. 14 is a front right perspective view of another alternate fiber optic module that supports twelve (12) fiber MPO fiber optic components and which can be installed in the fiber optic equipment tray of FIG. 3;

FIG. 15 is front right perspective view of another alternate fiber optic module that supports twenty-four (24) fiber MPO fiber optic components and which can be installed in the fiber optic equipment tray of FIG. 3;

FIG. 16 is a front perspective view of an alternate fiber optic module being installed in the fiber optic equipment tray of FIG. 3;

FIG. 17 is front right perspective view of the fiber optic module of FIG. 16;

FIG. 18 is a front view of the fiber optic module of FIGS. 16 and 17;

FIG. 19 is a front perspective view of another alternate fiber optic module being installed in the fiber optic equipment tray of FIG. 3;

FIG. 20 is front right perspective view of the fiber optic module of FIG. 19;

FIG. 21 is a front view of the fiber optic module of FIGS. 19 and 20;

FIG. 22 is a front perspective view of another alternate fiber optic module being installed in an alternate fiber optic equipment tray that can be installed in the chassis of FIG. 1;

FIGS. 23 is front right perspective view of the fiber optic module of FIG. 22;

FIG. 24 is a front view of the fiber optic module of FIGS. 22 and 23; and

FIG. 25 is a front perspective view of alternate exemplary 4-U size fiber optic chassis that can support the fiber optic equipment trays and fiber optic modules according to the fiber optic equipment tray and fiber optic modules disclosed.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to certain embodiments, examples of which are illustrated in the accompanying drawings, in which some, but not all features are shown. Indeed, embodiments disclosed herein may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Whenever possible, like reference numbers will be used to refer to like components or parts.

Embodiments disclosed in the detailed description include high-density fiber optic modules and fiber optic module housings and related equipment. In certain embodiments, the width and/or height of the front opening of fiber
optic modules and/or fiber optic module housings can be provided according to a designed relationship to the width and/or height, respectively, of a front side of the main body of the fiber optic modules and fiber optic module housings to support fiber optic components or connections. In this manner, fiber optic components can be installed in a given percentage or area of the front side of the fiber optic module to provide a high density of fiber optic connections for a given fiber optic component type(s). In another embodiment, the front openings of the fiber optic modules and/or fiber optic module housings can be provided to support a designed connection density of fiber optic components or connections for a given width and/or height of the front opening of the fiber optic module and/or fiber optic module housing. Embodiments disclosed in the detailed description also include high connection density and bandwidth fiber optic apparatuses and related equipment. In certain embodiments, fiber optic apparatuses are provided and comprise a chassis defining one or more U space fiber optic equipment units, wherein at least one of the one or more U space fiber optic equipment units is configured to support a given fiber optic connection density or bandwidth in a 1-U space, and for a given fiber optic component type(s).

[0012] In this regard, FIG. 1 illustrates exemplary 1-U size fiber optic equipment 10 from a front perspective view. The fiber optic equipment 10 supports high-density fiber optic modules that support a high fiber optic connection density and bandwidth in a 1-U space, as will be described in greater detail below. The fiber optic equipment 10 may be provided at a data distribution center or central office to support cable-to-cable fiber optic connections and to manage a plurality of fiber optic cable connections. As will be described in greater detail below, the fiber optic equipment 10 has one or more fiber optic equipment trays that each support one or more fiber optic modules. However, the fiber optic equipment 10 could also be adapted to support one or more fiber optic patch panels or other fiber optic equipment that supports fiber optic components and connectivity.

[0013] The fiber optic equipment 10 includes a fiber optic equipment chassis 12 ("chassis 12"). The chassis 12 is shown as being installed in a fiber optic equipment rack 14. The fiber optic equipment rack 14 contains two vertical rails 16A, 16B that extend vertically and include a series of apertures 18 for facilitating attachment of the chassis 12 inside the fiber optic equipment rack 14. The chassis 12 is attached and supported by the fiber optic equipment rack 14 in the form of shelves that are stacked on top of each other within the vertical rails 16A, 16B. As illustrated, the chassis 12 is attached to the vertical rails 16A, 16B. The fiber optic equipment rack 14 may support 1-U-sized shelves, with "U" equal to a standard 1.75 inches in height and seventeen (19) inches in width. In certain applications, the width of "U" may be twenty-three (23) inches. In this embodiment, the chassis 12 is 1-U in size; however, the chassis 12 could be provided in a size greater than 1-U as well.

[0014] As will be discussed in greater detail later below, the fiber optic equipment 10 includes a plurality of extendable fiber optic equipment trays 20 that each carries one or more fiber optic modules 22. The chassis 12 and fiber optic equipment trays 20 support fiber optic modules 22 that support high-density fiber optic modules and a fiber optic connection density and bandwidth connections in a given space, including in a 1-U space. FIG. 1 shows exemplary fiber optic components 23 disposed in the fiber optic modules 22 that support fiber optic connections. For example, the fiber optic components 23 may be fiber optic adapters or fiber optic connectors. As will also be discussed in greater detail later below, the fiber optic modules 22 in this embodiment can be provided such that the fiber optic components 23 can be disposed through at least eighty-five percent (85%) of the width of the front side or face of the fiber optic module 22, as an example. This fiber optic module 22 configuration may provide a front opening of approximately 90 millimeters (mm) or less wherein fiber optic components can be disposed through the front opening and at a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width of the front opening of the fiber optic modules 22 for simplex or duplex fiber optic components 23. In this example, six (6) duplex or twelve (12) simplex fiber optic components may be installed in each fiber optic module 22. The fiber optic equipment trays 20 in this embodiment support up to four (4) of the fiber optic modules 22 in approximately the width of a 1-U space, and three (3) fiber optic equipment trays 20 in the height of a 1-U space for a total of twelve (12) fiber optic modules 22 in a 1-U space. Thus, for example, if six (6) duplex fiber optic components were disposed in each of the twelve (12) fiber optic modules 22 installed in fiber optic equipment trays 20 of the chassis 12 as illustrated in FIG. 1, a total of one hundred forty-four (144) fiber optic connections, or seventy-two (72) duplex channels (i.e., transmit and receive channels), would be supported by the chassis 12 in a 1-U space. If five (5) duplex fiber adapters are disposed in each of the twelve (12) fiber optic modules 22 installed in fiber optic equipment trays 20 of the chassis 12, a total of one hundred twenty (120) fiber optic connections, or sixty (60) duplex channels, would be supported by the chassis 12 in a 1-U space. The chassis 12 also supports at least ninety-eight (98) fiber optic components in a 1-U space wherein at least one of the fiber optic components is a simplex or duplex fiber optic component.

[0015] If multi-fiber optic components were installed in the fiber optic modules 22, such as MPO components for example, higher fiber optic connection density and bandwidths would be possible over other chassis 12 that use similar fiber optic components. For example, if up to four (4) twelve (12) fiber MPO fiber optic components were disposed in each fiber optic module 22, and twelve (12) of the fiber optic modules 22 were disposed in the chassis 12 in a 1-U space, the chassis 12 would support up to five hundred seventy-six (576) fiber optic connections in a 1-U space. If up to four (4) twenty-four (24) fiber MPO fiber optic components were disposed in each fiber optic module 22, and twelve (12) of
the fiber optic modules 22 were disposed in the chassis 12, up to one thousand one hundred fifty-two (1152) fiber optic connections in a 1-U space.

[0016] FIG. 2 is a rear perspective close-up view of the chassis 12 of FIG. 1 with fiber optic modules 22 loaded with fiber optic components 23 and installed in fiber optic equipment trays 20 installed in the chassis 12. Module rails 28A, 28B are disposed on each side of each fiber optic module 22. The module rails 28A, 28B are configured to be inserted within tray channels 30 of module rail guides 32 disposed in the fiber optic equipment tray 20, as illustrated in more detail in FIGS. 3-5. Note that any number of module rail guides 32 can be provided. The fiber optic module 22 can be installed from both a front end 34 and a rear end 36 of the fiber optic equipment tray 20 in this embodiment. If it is desired to install the fiber optic module 22 in the fiber optic equipment tray 20 from the rear end 36, a front end 33 of the fiber optic module 22 can be inserted from the rear end 36 of the fiber optic equipment tray 20. More specifically, the front end 33 of the fiber optic module 22 is inserted into the tray channels 30 of the module rail guides 32. The fiber optic module 22 can then be pushed forward within the tray channels 30 until the fiber optic module 22 reaches the front end 34 of the module rail guides 32. The fiber optic modules 22 can be moved towards the front end 34 until the fiber optic modules 22 reach a stop or locking feature disposed in the front end 34 as will described later in this application. FIG. 6 also illustrates the fiber optic equipment tray 20 without installed fiber optic modules 22 to illustrate the tray channels 30 and other features of the fiber optic equipment tray 20.

[0017] The fiber optic module 22 can be locked into place in the fiber optic equipment tray 20 by pushing the fiber optic module 22 forward to the front end 33 of the fiber optic equipment tray 20. A locking feature in the form of a front stop 38 is disposed in the module rail guides 32, as illustrated in FIG. 3 and in more detail in the close-up view in FIG. 4. The front stop 38 prevents the fiber optic module 22 from extending beyond the front end 34, as illustrated in the close-up view of the fiber optic equipment tray 20 with installed fiber optic modules 22 in FIG. 5. When it is desired to remove a fiber optic module 22 from the fiber optic equipment tray 20, a front module tab 40 also disposed in the module rail guides 32 and coupled to the front stop 38 can be pushed downward to engage the front stop 38. As a result, the front stop 38 will move outward away from the fiber optic module 22 such that the fiber optic module 22 is not obstructed from being pulled forward. The fiber optic module 22, and in particular its module rails 28A, 28B (FIG. 2), can be pulled forward along the module rail guides 32 to remove the fiber optic module 22 from the fiber optic equipment tray 20.

[0018] The fiber optic module 22 can also be removed from the rear end 36 of the fiber optic equipment tray 20. To remove the fiber optic module 22 from the rear end 36 of the fiber optic equipment tray 20, a latch 44 is disengaged by pushing a lever 46 (see FIGS. 2 and 3; see also, FIGS. 10A and 10B) inward towards the fiber optic module 22 to release the latch 44 from the module rail guide 32. To facilitate pushing the lever 46 inward towards the fiber optic module 22, a finger hook 48 is provided adjacent to the lever 46 so the lever 46 can easily be squeezed into the finger hook 48 by a thumb and index finger.

[0019] With continuing reference to FIG. 3-6, the fiber optic equipment tray 20 may also contain extension members 50. Routing guides 52 may be conveniently disposed on the extension members 50 to provide routing for optical fibers or fiber optic cables connected to fiber optic components 23 disposed in the fiber optic modules 22 (FIG. 3). The routing guides 52 on the ends of the fiber optic equipment tray 20 may be angled with respect to the module rail guides 32 to route optical fibers or fiber optic cables at an angle to the sides of the fiber optic equipment tray 20. Pull tabs 54 may also be connected to the extension members 50 to provide a means to allow the fiber optic equipment tray 20 to easily be pulled out from and pushed into the chassis 12.

[0020] As illustrated in FIGS. 3 and 6, the fiber optic equipment tray 20 also contains tray rails 56. The tray rails 56 are configured to be disposed in tray guides 58 disposed in the chassis 12 to retain and allow the fiber optic equipment trays 20 to move in and out of the chassis 12, as illustrated in FIG. 7. More detail regarding the tray rails 56 and their coupling to the tray guides 58 in the chassis 12 is discussed below with regard to FIGS. 8 and 9A-9B. The fiber optic equipment trays 20 can be moved in and out of the chassis 12 by their tray rails 56 moving within the tray guides 58. In this manner, the fiber optic equipment trays 20 can be independently movable about the tray guides 58 in the chassis 12. FIG. 7 illustrates a front perspective view of one fiber optic equipment tray 20 pulled out from the chassis 12 among three (3) fiber optic equipment trays 20 disposed within the tray guides 58 of the chassis 12. The tray guides 58 may be disposed on both a left side end 60 and a right side end 62 of the fiber optic equipment tray 20. The tray guides 58 are installed opposite and facing each other in the chassis 12 to provide complementary tray guides 58 for the tray rails 56 of the fiber optic equipment trays 20 received therein. If it is desired to access a particular fiber optic equipment tray 20 and/or a particular fiber optic module 22 in a fiber optic equipment tray 20, the pull tab 54 of the desired fiber optic equipment tray 20 can be pulled forward to cause the fiber optic equipment tray 20 to extend forward out of the chassis 12, as illustrated in FIG. 7. The fiber optic module 22 can be removed from the fiber optic equipment tray 20 as previously discussed. When access is completed, the fiber optic equipment tray 20 can be pushed back into the chassis 12 wherein the tray rails 56 move within the tray guides 58 disposed in the chassis 12.

[0021] FIGS. 8A and 8B are left perspective views of an exemplary tray guides 58,58' that can be disposed in the chassis 12 of FIG. 1. The tray guide 58 of FIG. 8A is configured to support up to two (2) tray rails 56 in a 1-U space. The tray guide 58' of FIG. 8B is configured to support up to three (3) tray rails 56 per 1-U space, as illustrated in FIG.
1. The tray guides 58,58' contain like features and thus the description below with regard to tray guide 58 in FIG. 8A is equally applicable to the tray guide 58' of FIG. 8B. Like features or elements between tray guides 58,58' are illustrated with common element numbers, except that such features in tray guide 58' will be appended with an apostrophe (').

[0022] As discussed above, the tray guides 58,58' are configured to receive fiber optic equipment trays 20 supporting one or more fiber optic modules 22 in the chassis 12. The tray guides 58,58' allow the fiber optic equipment trays 20 to be pulled out from the chassis 12, as illustrated in FIG. 7. The tray guide 58 in FIG. 8A is comprised of a guide panel 64. The guide panel 64 is comprised of an elongated member 65. The guide panel 64 may be constructed out of any material desired, including but not limited to a polymer or metal. The guide panel 64 contains a series of apertures 66 to facilitate attachment of the guide panel 64 to the chassis 12, as illustrated in FIG. 8A. Guide members 68 are disposed in the guide panel 64 and are configured to receive the tray rail 56 of the fiber optic equipment tray 20. Two (2) guide members 68 are disposed in the guide panel 64 in the embodiment of FIG. 8A to be capable of receiving up to two (2) tray rails 56 of three (3) fiber optic equipment trays 20 in a 1-U space. Three (3) guide members 68' are disposed in the guide panel 64' in the embodiment of FIG. 8B to be capable of receiving up to three (3) tray rails 56 of three (3) fiber optic equipment trays 20 in a 1-U space. However, any number of guide members 68,68' desired may be provided in the tray guides 58,58' to cover sizes less than or greater than a 1-U space. As illustrated in FIG. 8A, the guide members 68 each include guide channels 70 configured to receive and allow tray rails 56 to move along the guide channels 70 for translation of the fiber optic equipment trays 20 about the chassis 12.

[0023] With reference to FIG. 8A, leaf springs 72 are disposed in each of the guide members 68 of the tray guide 58 and are each configured to provide stopping positions for the tray rails 56 during movement of the fiber optic equipment tray 20 in the guide members 68. The leaf springs 72 are disposed between ends 73 disposed in the guide member 68 to give leaf springs 72 spring action. The leaf springs 72 each contain protrusions 74 that are configured to receive detents 76 (FIG. 9A and 9B) disposed in the tray rails 56 to provide stopping or resting positions. The tray rails 56 contain mounting platforms 75 that are used to attach the tray rails 56 to the fiber optic equipment trays 20. It may be desirable to provide stopping positions in the tray guide 56 to allow the fiber optic equipment trays 20 to have stopping positions when moved in and out of the chassis 12. Stopping positions allow the technician to impart a certain force to pull or push the fiber optic tray 20 about the guide panel 64 so that the fiber optic equipment tray 20 is retained in place when not pulled or pushed. However, the force can also be designated to allow a technician to easily push in or pull out the fiber optic equipment tray 20 into and from the guide panel 64 when desired, especially when the fiber optic equipment tray 20 is located above the technician. In this regard and by example, two (2) detents 76 in the tray rail 56 are disposed in two (2) protrusions 74 in the tray guide 58 at any given time. When the fiber optic equipment tray 20 is fully retracted into the chassis 12 in a first stopping position, the two (2) detents 76 of the tray rail 56 are disposed in the one protrusion 74 adjacent a rear end 77 of the guide channel 70 and the middle protrusion 74 disposed between the rear end 77 and a front end 78 of the guide channel 70. When the fiber optic equipment tray 20 is pulled out from the chassis 12, the two (2) detents 76 of the tray rail 56 are disposed in the one protrusion 74 adjacent the front end 78 of the guide channel 70 and the middle protrusion 74 disposed between the rear end 77 and the front end 78 of the guide channel 70. Thus, the stopping or resting positions provided by the engagement of the detents 76 of the leaf springs 72 with the protrusions 74 of the tray rail 56 in this embodiment are provided to require force on the guide panel 64 to overcome the stopping position to translate the tray rail 56 of a fiber optic equipment tray 20 disposed within the guide member 68.

[0024] In this embodiment, each leaf spring 72 is designed to require approximately two (2) pounds (lbs.) of pulling force to allow protrusion 74 in the leaf spring 72 to overcome the protrusion 74 disposed in the tray rail 56 for a total of four (4) lbs. pulling force (i.e., two (2) detents 76 in the tray rail 56 are engaged with two (2) protrusions 74 disposed in two (2) leaf springs 72). The pulling force required to overcome the engagement of the protrusion 74 in the detents 76 could be designated to be any pulling force desired. For example, the pulling force required to overcome the engagement of the protrusion 74 in the detents 76 could be designated to be greater than the pulling force required to engage or disengage a fiber optic connector from a fiber optic module 22 supported by the fiber optic equipment tray 20. The leaf springs 72 in this embodiment are designed to each provide the same force, but such does not have to be the case. Further, the guide panel 64 and tray rail 56 could be designed to provide fewer stopping positions or only provide one protrusion 74 that is engaged with one detent 76 in each stopping or resting position.

[0025] When the tray rail 56 is in a stopped position, two (2) protrusions 74 disposed in two (2) leaf springs 72 are engaged with two (2) detents 76 in the tray rail 56, as previously discussed. In this embodiment, when the tray rail 56 is in a stopping position, the leaf springs 72 and their protrusions 74 and complimentary detents 76 in the tray rail 56 are designed cooperatively such that the detents 76 do not impart a force on the protrusion 74. Thus, the leaf springs 72 are in an unstressed state when the tray rail 56 is in a stopped position. This may be advantageous if the leaf springs 72 are made out of a material, such as a polymer material for example, where creep can occur over time, thus reducing the effectiveness of the leaf spring 72 over time. However, this feature is not a requirement for the design. The tray guide 58' in FIG. 8B can also be employed as described above with regard to the tray guide 58 of FIG. 8A to support and allow movement of three (3) tray rails 56.

[0026] As the tray rail 56 is pulled within the guide channel 70, a protrusion 80 disposed in the tray rail 56 and illustrated...
in FIGS. 9A and 9B is biased to pass over transition members 82 disposed between the leaf springs 72, as illustrated in FIG. 8. The protrusion 80 is provided in a leaf spring 81 disposed in the tray rail 56, as illustrated in FIGS. 9A and 9B. The transition members 82 have inclined surfaces 84 that allow the protrusion 80 to pass over the transition members 82 as the fiber optic equipment tray 20 is being translated with the guide channel 70. As the protrusion 80 contains the transition members 82, the force imparted onto the protrusion 80 causes the leaf spring 81 to bend inward to allow the protrusion 80 to pass over the transition member 82. To prevent the tray rail 56 and thus the fiber optic equipment tray 20 from being extended beyond the front end 78 and rear end 77 of the guide channel 70, stopping members 86 are disposed at the front end 78 and rear end 77 of the guide channel 70. The stopping members 86 do not have an inclined surface; thus the protrusion 80 in the tray rail 56 abuts against the stopping member 86 and is prevented from extending over the stopping member 86 and outside of the front end 78 of the guide channel 70.

[0027] Against the background of the above disclosed embodiment of a 1-U chassis 12 and fiber optic equipment trays 20 and fiber optic modules 22 that can installed therein, the form factor of the fiber optic module 22 will now be described. The form factor of the fiber optic module 22 allows a high density of fiber optic components 23 to be disposed within a certain percentage area of the front of the fiber optic module 22 thus supporting a particular fiber optic connection density and bandwidth for a given type of fiber optic component 23. When this fiber optic module 22 form factor is combined with the ability to support up to twelve (12) fiber optic modules 22 in a 1-U space, as described by the exemplary chassis 12 example above, a higher fiber optic connection density and bandwidth is supported and possible.

[0028] In this regard, FIGS. 10A and 10B are right and left perspective views of the exemplary fiber optic module 22. As discussed above, the fiber optic module 22 can be installed in the fiber optic equipment trays 20 to provide fiber optic connections in the chassis 12. The fiber optic module 22 is comprised of a main body 90 receiving a cover 92. An internal chamber 94 (FIG. 11) disposed inside the main body 90 and the cover 92 and is configured to receive or retain optical fibers or a fiber optic cable harness, as will be described in more detail below. The main body 90 is disposed between a front side 96 and a rear side 98 of the main body 90. Fiber optic components 23 can be disposed through the front side 96 of the main body 90 and configured to receive fiber optic connectors connected to fiber optic cables (not shown).

In this example, the fiber optic components 23 are duplex LC fiber optic adapters that are configured to receive and support connections with duplex LC fiber optic connectors. However, any fiber optic connection type desired can be provided in the fiber optic module 22. The fiber optic components 23 are connected to a fiber optic component 100 disposed through the rear side 98 of the main body 90. In this manner, a connection to the fiber optic component 23 creates a fiber optic connection to the fiber optic component 100. In this example, the fiber optic component 100 is a multi-fiber MPO fiber optic adapter equipped to establish connections to multiple optical fibers (e.g., either twelve (12) or twenty-four (24) optical fibers). The fiber optic module 22 may also manage polarity between the fiber optic components 23, 100.

[0029] The module rails 28A, 28B are disposed on each side 102A, 102B of the fiber optic module 22. As previously discussed, the module rails 28A, 28B are configured to be inserted within the module rail guides 32 in the fiber optic equipment tray 20, as illustrated in FIG. 3. In this manner, when it is desired to install a fiber optic module 22 in the fiber optic equipment tray 20, the front side 96 of the fiber optic module 22 can be inserted from either the front end 33 or the rear end 36 of the fiber optic equipment tray 20, as previously discussed.

[0030] FIG. 11 illustrates the fiber optic module 22 in an exploded view with the cover 92 of the fiber optic module 22 removed to illustrate the internal chamber 94 and other internal components of the fiber optic module 22. FIG. 12 illustrates the fiber optic module 22 assembled, but without the cover 92 installed on the main body 90. The cover 92 includes notches 106 disposed in sides 108, 110 that are configured to interlock with protrusions 112 disposed on the sides 102A, 102B of the main body 90 of the fiber optic modules 22 when the cover 92 is attached to the main body 90 to secure the cover 92 to the main body 90. The cover 92 also contains notches 114, 116 disposed on a front side 118 and rear side 120, respectively, of the cover 92. The notches 114, 116 are configured to interlock with protrusions 122, 124 disposed in the front side 96 and rear end 98, respectively, of the main body 90 when the cover 92 is attached to the main body 90 to also secure the cover 92 to the main body 90. FIG. 12 does not show protrusions 122, 124.

[0031] With continuing reference to FIG. 11, the fiber optic components 23 are disposed through a front opening 126 disposed along a longitudinal axis L1 in the front side 96 of the main body 90. In this embodiment, the fiber optic components 23 are duplex LC adapters 128, which support single or duplex fiber connections and connectors. The duplex LC adapters 128 in this embodiment contain protrusions 130 that are configured to engage with orifices 135 disposed on the main body 90 to secure the duplex LC adapters 128 in the main body 90 in this embodiment. A cable harness 134 is disposed in the internal chamber 94 with fiber optic connectors 136, 138 disposed on each end of optical fibers 139 connected to the duplex LC adapters 128 and the fiber optic component 100 disposed in the rear side 98 of the main body 90. The fiber optic component 100 in this embodiment is a twelve (12) fiber MPO fiber optic adapter 140 in this embodiment. Two vertical members 142A, 142B (i.e., fiber guides) are disposed in the internal chamber 94 of the main body 90, as illustrated in FIG. 12, to retain the looping of the optical fibers 139 of the cable harness 134. The vertical members 142A, 142B and the distance therebetween are designed to provide a bend radius R in the optical fibers 139 no greater than forty (40) millimeters and preferably twenty-five (25) millimeters or less, thereby aiding in
maintaining a high fiber optic connector density.

[0032] Other structures besides vertical members 142A, 142B of FIG. 12 are possible for fiber guides that retain and/or route the cable harness 134 within the module to inhibit damage, organize, maintain a bend radius and/or make the device easier to assemble. The fiber guide structure is also useful for maintaining a bend radius R for the optical fibers.

By way of example, FIG. 12A shows a perspective top view of another fiber optic module 22 with the cover removed showing the fiber optic harness 134 installed within a plurality of fiber guides 143, 144 for retaining and routing the optical fibers of fiber optic harness 134. Any suitable shape for the fiber guides are possible along with a suitable number of fiber guides in the module. Moreover, one or more of the fiber guides can be shaped to accommodate a furcation body for the ribbon to individual fiber transition or the like. In this embodiment, fiber guides 143, 144 have two different shapes and have three different locations. Specifically, fiber guides 143 are configured as L-guides and are located at a suitably spaced apart locations and fiber guide 144 is a J-guide spaced apart from fiber guides 143. Consequently, the assembler can easily and quickly install the cable harness 134 into the internal chamber 94 of main body 90 using fiber guides 143, 144. Moreover, the fiber guides 143, 144 ensure an adequate bend radius for the optical fibers of the fiber optic harness 134 and inhibits pinching of the optical fibers when installing the cover. Fiber guides 143, 144 may be configured in any suitable arrangement such molded with main body 90 or configured separate components. For instance, other arrangements may have retention pins molded into main body 90 for receiving and securing discrete fiber guides using a friction fit and/or adhesive; however, this adds manufacturing complexity.

[0033] FIG. 13 illustrates a front view of the fiber optic module 22 without loaded fiber optic components 23 in the front side 96 to further illustrate the form factor of the fiber optic module 22. As previously discussed, the front opening 126 is disposed through the front side 96 of the main body 90 to receive the fiber optic components 23. The greater the width \( W_1 \) of the front opening 126, the greater the number of fiber optic components 23 that may be disposed in the fiber optic module 22. Greater numbers of fiber optic components 23 equates to more fiber optic connections, which supports higher fiber optic connectivity and bandwidth. However, the larger the width \( W_1 \) of the front opening 126, the greater the area required to be provided in the chassis 12 for the fiber optic module 22. Thus, in this embodiment, the width \( W_1 \) of the front opening 126 is design to be at least eighty-five percent (85%) of the width \( W_2 \) of the front side 96 of the main body 90 of the fiber optic module 22. The greater the percentage of the width \( W_1 \) to width \( W_2 \), the larger the area provided in the front opening 126 to receive fiber optic components 23 without increasing width \( W_2 \). Width \( W_3 \), the overall width of the fiber optic module 22, may be 86.6 mm or 4.5 inches in this embodiment. The overall depth \( D_3 \) of the fiber optic module 22 is 113.9 mm or 4.5 inches in this embodiment (FIG. 12). As previously discussed, the fiber optic module 22 is designed such that four (4) fiber optic modules 22 can be disposed in a 1-U width space in the fiber optic equipment tray 20 in the chassis 12. The width of the chassis 12 is designed to accommodate a 1-U space width in this embodiment.

[0034] With three (3) fiber optic equipment trays 20 disposed in the 1-U height of the chassis 12, a total of twelve (12) fiber optic modules 22 can be supported in a given 1-U space. Supporting up to twelve (12) fiber optic connections per fiber optic module 22 as illustrated in the chassis 12 in FIG. 1 equates to the chassis 12 supporting up to one hundred forty-four (144) fiber optic connections, or seventy-two (72) duplex channels, in a 1-U space in the chassis 12 (i.e., twelve (12) fiber optic connections X three (3) fiber optic modules 22 in a 1-U space). Thus, the chassis 12 is capable of supporting up to one hundred forty-four (144) fiber optic connections in a 1-U space by twelve (12) simplex or six (6) duplex fiber optic adapters being disposed in the fiber optic modules 22. Supporting up to ten (10) fiber optic connections per fiber optic module 22 equates to the chassis 12 supporting one hundred twenty (120) fiber optic connections, or sixty (60) duplex channels, in a 1-U space in the chassis 12 (i.e., ten (10) fiber optic connections X twelve (12) fiber optic modules 22 in a 1-U space). Thus, the chassis 12 is also capable of supporting up to one hundred twenty (120) fiber optic connections in a 1-U space by ten (10) simplex or five (5) duplex fiber optic adapters being disposed in the fiber optic modules 22.

[0035] This embodiment of the chassis 12 and fiber optic module 22 disclosed herein can support a fiber optic connection density within a 1-U space wherein the area occupied by the fiber optic component 23 in twelve (12) fiber optic modules 22 in a 1-U space represents at least fifty percent (50%) of the total fiber optic equipment rack 14 area in a 1-U space (see FIG. 1). In the case of twelve (12) fiber optic modules 22 provided in a 1-U space in the chassis 12, the 1-U space is comprised of the fiber optic components 23 occupying at least seventy-five percent (75%) of the area of the front side 96 of the fiber optic module 22.

[0036] Two (2) duplexed optical fibers to provide one (1) transmission/reception pair can allow for a data rate of ten (10) Gigabits per second in half-duplex mode or twenty (20) Gigabits per second in full-duplex mode. Thus, with the above-described embodiment, providing at least seventy-two (72) duplex transmission and reception pairs in a 1-U space employing at least one duplex or simplex fiber optic component can support a data rate of at least seven hundred twenty (720) Gigabits per second in half-duplex mode in a 1-U space or at least one thousand four hundred forty (1440) Gigabits per second in a 1-U space in full-duplex mode if employing a ten (10) Gigabit transceiver. This configuration can also support at least six hundred (600) Gigabits per second in half-duplex mode in a 1-U space and at least one thousand two hundred (1200) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a one hundred (100) Gigabit transceiver. This configuration can also support at least four hundred eighty (480) Gigabits per
second in half-duplex mode in a 1-U space and nine hundred sixty (960) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a forty (40) Gigabit transceiver. At least sixty (60) duplex transmission and reception pairs in a 1-U space can allow for a data rate of at least six hundred (600) Gigabits per second in a 1-U space in half-duplex mode or at least one thousand two hundred (1200) Gigabits per second in a 1-U space in full-duplex mode when employing a ten (10) Gigabit transceiver. At least forty nine (49) duplex transmission and reception pairs in a 1-U space can allow for a data rate of at least four hundred eighty-one (481) Gigabits per second in half-duplex mode or at least nine hundred sixty-two (962) Gigabits per second in a 1-U space in full-duplex mode when employing a ten (10) Gigabit transceiver.

[0037] The width $W_2$ of front opening 126 could be designed to be greater than eighty-five percent (85%) of the width $W_1$ of the front side 96 of the main body 90 of the fiber optic module 22. For example, the width $W_1$ could be designed to be between ninety percent (90%) and ninety-nine percent (99%) of the width $W_2$. As an example, the width $W_1$ could be less than ninety (90) mm. As another example, the width $W_1$ could be less than eighty-five (85) mm or less than eighty (80) mm. For example, the width $W_1$ may be eighty-three (83) mm and width $W_2$ may be eighty-five (85) mm, for a ratio of width $W_1$ to width $W_2$ of 97.6%. In this example, the front opening 126 may support twelve (12) fiber optic connections in the width $W_1$ to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width $W_1$ of the front opening 126. Further, the front opening 126 of the fiber optic module 22 may support twelve (12) fiber optic connections in the width $W_1$ to support a fiber optic connection density of at least one fiber optic connection per 6.9 mm of width $W_1$ of the front opening 126.

[0038] Further as illustrated in FIG. 13, height $H_1$ of front opening 126 could be designed to be at least ninety percent (90%) of height $H_2$ of the front side 96 of the main body 90 of the fiber optic module 22. In this manner, the front opening 126 has sufficient height to receive the fiber optic components 23, and such that three (3) fiber optic modules 22 can be disposed in a 1-U space height. As an example, height $H_1$ could be twelve (12) mm or less or ten (10) mm or less. As an example, height $H_1$ could be ten (10) mm and height $H_2$ could be eleven (11) mm (or 7/16 inches), for a ratio of height $H_1$ to width $H_2$ of 90.9%.

[0039] Alternate fiber optic modules with alternative fiber optic connection densities are possible. FIG. 14 is a front perspective view of an alternate fiber optic module 22′ that can be installed in the fiber optic equipment tray 20 of FIG. 1. The form factor of the fiber optic module 22′ is the same as the form factor of the fiber optic module 22 illustrated in FIGS. 1-13. However, in the fiber optic module 22′ of FIG. 14, two (2) MPO fiber optic adapters 150 are disposed through the front opening 126 of the fiber optic module 22′. The MPO fiber optic adapters 150 are connected to two (2) MPO fiber optic adapters 152 disposed in the rear side 98 of the main body 90 of the fiber optic module 22′. Thus, if the MPO fiber optic adapters 150 each support twelve (12) fibers, the fiber optic module 22′ can support up to twenty-four (24) fiber optic connections. Thus, in this example, if up to twelve (12) fiber optic modules 22′ are provided in the fiber optic equipment trays 20 of the chassis 12, up to two hundred eighty-eight (288) fiber optic connections can be supported by the chassis 12 in a 1-U space. Further in this example, the front opening 126 of the fiber optic module 22′ may support twenty-four (24) fiber optic connections in the width $W_1$ (FIG. 13) to support a fiber optic connection density of at least one fiber optic connection per 3.4-3.5 mm of width $W_1$ of the front opening 126. It should be understood that the discussion with regard to modules may also apply to a panel. For purposes of this disclosure, a panel may have one or more adapters on one side and no adapters on the opposite side.

[0040] Thus, with the above-described embodiment, providing at least two-hundred eighty-eight (288) duplex transmission and reception pairs in a 1-U space employing at least one twelve (12) fiber MPO fiber optic components can support a data rate of at least two thousand eight hundred eighty (2880) Gigabits per second in half-duplex mode in a 1-U space or at least five thousand seven hundred sixty (5760) Gigabits per second in a 1-U space in full-duplex mode if employing a ten (10) Gigabit transceiver. This configuration can also support at least four thousand eight hundred (4800) Gigabits per second in half-duplex mode in a 1-U space and nine thousand six hundred (9600) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a one hundred (100) Gigabit transceiver. This configuration can also support at least one thousand nine hundred twenty (1920) Gigabits per second in half-duplex mode in a 1-U space and three thousand eight hundred forty (3840) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a forty (40) Gigabit transceiver. This configuration also supports a data rate of at least four thousand three hundred twenty-two (4322) Gigabits per second in full-duplex mode in a 1-U space when employing a ten (10) Gigabit transceiver employing at least one twelve (12) fiber MPO fiber optic component, or two thousand one hundred sixty-one (2161) Gigabits per second in full-duplex mode in a 1-U space when employing a ten (10) Gigabit transceiver employing at least twenty-four (24) fiber MPO fiber optic component.

[0041] If the MPO fiber optic adapters 150 in the fiber optic module 22′ support twenty-four (24) fibers, the fiber optic module 22′ can support up to forty-eight (48) fiber optic connections. Thus, in this example, if up to twelve (12) fiber optic modules 22′ are provided in the fiber optic equipment trays 20 of the chassis 12, up to five hundred seventy-six (576) fiber optic connections can be supported by the chassis 12 in a 1-U space if the fiber optic modules 22′ are disposed in the fiber optic equipment trays 20. Further, in this example, the front opening 126 of the fiber optic module 22′ may support up to forty-eight (48) fiber optic connections in the width $W_1$ to support a fiber optic connection density of at least
one fiber optic connection per 1.7 mm of width \( W_1 \) of the front opening 126.

[0042] FIG. 15 is a front perspective view of another alternate fiber optic module 22" that can be installed in the fiber optic equipment tray 20 of FIG. 1. The form factor of the fiber optic module 22" is the same as the form factor of the fiber optic module 22 illustrated in FIGS. 1-13. However, in the fiber optic module 22", four (4) MPO fiber optic adapters 154 are disposed through the front opening 126 of the fiber optic module 22". The MPO fiber optic adapters 154 are connected to four (4) MPO fiber optic adapters 156 disposed in the rear end 98 of the main body 90 of the fiber optic module 22". Thus, if the MPO fiber optic adapters 150 support twelve (12) fibers, the fiber optic module 22" can support up to forty-eight (48) fiber optic connections. Thus, in this example, if up to twelve (12) fiber optic modules 22" are provided in the fiber optic equipment trays 20 of the chassis 12, up to five hundred seventy-six (756) fiber optic connections can be supported by the chassis 12 in a 1-U space. Further, in this example, the front opening 126 of the fiber optic module 22" may support twenty-four (24) fiber optic connections in the width \( W_1 \) to support a fiber optic connection density of at least one fiber optic connection per 1.7 mm of width \( W_1 \) of the front opening 126.

[0043] If the four (4) MPO fiber optic adapters 154 disposed in the fiber optic module 22" support twenty-four (24) fibers, the fiber optic module 22" can support up to ninety-six (96) fiber optic connections. Thus, in this example, if up to twelve (12) fiber optic modules 22" are provided in the fiber optic equipment trays 20 of the chassis 12, up to one thousand one hundred fifty-two (1152) fiber optic connections can be supported by the chassis 12 in a 1-U space. Further, in this example, the front opening 126 of the fiber optic module 22" may support up to ninety-six (96) fiber optic connections in the width \( W_1 \) to support a fiber optic connection density of at least one fiber optic connection per 0.85 mm of width \( W_1 \) of the front opening 126.

[0044] Further, with the above-described embodiment, providing at least five hundred seventy-six (576) duplex transmission and reception pairs in a 1-U space employing at least one twenty-four (24) fiber MPO fiber optic component can support a data rate of at least five thousand seven hundred sixty (5760) Gigabits per second in half-duplex mode in a 1-U space or at least eleven thousand five hundred twenty (11520) Gigabits per second in a 1-U space in full-duplex mode if employing a ten (10) Gigabit transceiver. This configuration can also support at least four thousand eight hundred (4800) Gigabits per second in half-duplex mode in a 1-U space and at least nine thousand six hundred (9600) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a one hundred (100) Gigabit transceiver. This configuration can also support at least three thousand eight hundred forty (3840) Gigabits per second in half-duplex mode in a 1-U space and at least seven thousand six hundred eighty (7680) Gigabits per second in full-duplex mode in a 1-U space, respectively, if employing a forty (40) Gigabit transceiver. This configuration also supports a data rate of at least eight thousand six hundred forty two (8642) Gigabits per second in full-duplex mode in a 1-U space when employing a ten (10) Gigabit transceiver employing at least one twenty-four (24) fiber MPO fiber optic component, or four thousand three hundred twenty one (4321) Gigabits per second in full-duplex mode in a 1-U space when employing a ten (10) Gigabit transceiver employing at least one twenty-four (24) fiber MPO fiber optic component.

[0045] FIG. 16 illustrates an alternate fiber optic module 160 that may be provided in the fiber optic equipment trays 20 to support fiber optic connections and connection densities and bandwidths. FIG. 17 is a right front perspective view of the fiber optic module 160 of FIG. 16. In this embodiment, the fiber optic module 160 is designed to fit across two sets of module rail guides 32. A channel 162 is disposed through a center axis 164 of the fiber optic module 160 to receive a module rail guide 32 in the fiber optic equipment tray 20. Module rails 165A, 165B, similar to the module rails 28A, 28B of the fiber optic module 22 of FIGS. 1-13, are disposed on the inside the channel 162 of the fiber optic module 160 and configured to engage with tray channels 30 in the fiber optic equipment tray 20. Module rails 166A, 166B, similar to the module rails 28A, 28B of the fiber optic module 22 of FIGS. 1-13, are disposed on each side 168, 170 of the fiber optic module 160 that are configured to engage with tray channels 30 in the fiber optic equipment tray 20. The module rails 166A, 166B are configured to engage with tray channels 30 in a module rail guide 32 disposed between module rail guides 32 engaged with the module rail guides 32 disposed on the sides 168, 170 of the fiber optic module 160.

[0046] Up to twenty-four (24) fiber optic components 23 can be disposed in a front side 172 of the fiber optic module 160. In this embodiment, the fiber optic components 23 are comprised of up to twelve (12) duplex LC fiber optic adapters, which are connected to one twenty-four (24) fiber MPO fiber optic connector 174 disposed in a rear end 176 of the fiber optic module 160. Thus, with three (3) fiber optic equipment trays 20 disposed in the height of the chassis 12, a total of six (6) fiber optic modules 160 can be supported in a given 1-U space. Supporting up to twenty-four (24) fiber optic connections per fiber optic module 160 equates to the chassis 12 supporting up to one hundred forty-four (144) fiber optic connections, or seventy-two (72) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty-four (24) fiber optic connections X six (6) fiber optic modules 160 in a 1-U space). Thus, the chassis 12 is capable of supporting up to one hundred forty-four (144) fiber optic connections in a 1-U space by twenty-four (24) simplex or twelve (12) duplex fiber optic adapters being disposed in the fiber optic modules 160. Supporting up to twenty (20) fiber optic connections per fiber optic module 160 equates to the chassis 12 supporting one hundred twenty (120) fiber optic connections, or sixty (60) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty (20) fiber optic connections X six (6) fiber optic modules 160 in a 1-U space). Thus, the chassis 12 is also capable of supporting up to one hundred twenty (120) fiber optic connections in a 1-U space by twenty (20) simplex or ten (10) duplex fiber optic adapters being disposed in the
Fiber optic modules 160.

[0047] FIG. 18 illustrates a front view of the fiber optic module 160 of FIGS. 16-17 without loaded fiber optic components 23 in the front side 172 to further illustrate the form factor of the fiber optic module 160 in this embodiment. Front openings 178A, 178B disposed on each side of the channel 162 are disposed through the front side 172 of a main body 180 of the fiber optic module 160 to receive the fiber optic components 23. The widths W1 and W2 and the heights H1 and H2 are the same as in the fiber optic module 22 illustrated in FIG. 13. Thus, in this embodiment, the widths W1 of front openings 178A, 178B are designed to be at least eighty-five percent (85%) of the width W2 of the front side 172 of the main body 180 of the fiber optic module 160. The greater the percentage of the width W1 to width W2, the larger the area provided in the front openings 178A, 178B to receive fiber optic components 23 without increasing width W2.

[0048] The width W1 of the front openings 178A, 178B could each be designed to be greater than eighty-five percent (85%) of the width W2 of the front side 172 of the main body 180 of the fiber optic module 160. For example, the width W1 could be designed to be between ninety percent (90%) and ninety-nine percent (99%) of the width W2. As an example, the width W1 could be less than ninety (90) mm. As another example, the width W1 could be less than eighty-five (85) mm or less than eighty (80) mm. For example, width W1 may be eighty-three (83) mm and width W2 may be eighty-five (85) mm, for a ratio of width W1 to width W2 of 97.6%. In this example, the front openings 178A, 178B may support twelve (12) fiber optic connections in the widths W1 to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width W1 of the front openings 178A, 178B. Further, each of the front openings 178A, 178B may support twelve (12) fiber optic connections in the widths W1 to support a fiber optic connection density of at least one fiber optic connection per 6.9 mm of width W1 of the front openings 178A, 178B.

[0049] Further as illustrated in FIG. 18, the height H1 of front openings 178A, 178B could be designed to be at least ninety percent (90%) of the height H2 of the front side 172 of the main body 180 of the fiber optic module 160. In this manner, the front openings 178A, 178B have sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 160 can be disposed in the height of a 1-U space. As an example, the height H1 could be twelve (12) mm or less or ten (10) mm or less. As an example, the height H1 could be ten (10) mm and height H2 could be eleven (11) mm, for a ratio of height H1 to height H2 of 90.9%.

[0050] FIG. 19 illustrates another alternate fiber optic module 190 that may be provided in the fiber optic equipment trays 20 to support fiber optic connections and connection densities and bandwidths. FIG. 20 is a right front perspective view of the fiber optic module 190 of FIG. 19. In this embodiment, the fiber optic module 190 is designed to fit across two sets of module rail guides 32. A longitudinal receiver 192 is disposed through a center axis 194 and is configured to receive a module rail guide 32 in the fiber optic equipment tray 20 through an opening 193 in the receiver 192. Module rails 195A, 195B, similar to the module rails 28A, 28B of the fiber optic module 22 of FIGS. 1-13, are disposed on each side 198, 200 of the fiber optic module 190 that are configured to engage with tray channels 30 in the fiber optic equipment tray 20.

[0051] Up to twenty-four (24) fiber optic components 23 can be disposed in a front side 202 of the fiber optic module 190. In this embodiment, the fiber optic components 23 are comprised of up to twelve (12) duplex LC fiber optic adapters, which are connected to one twenty-four (24) fiber MPO fiber optic connector 204 disposed in a rear end 206 of the fiber optic module 190. Thus, with three (3) fiber optic equipment trays 20 disposed in the height of the chassis 12, a total of six (6) fiber optic modules 190 can be supported in a given 1-U space. Supporting up to twenty-four (24) fiber optic connections per fiber optic module 190 equates to the chassis 12 supporting up to one hundred forty-four (144) fiber optic connections, or seventy-two (72) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty-four (24) fiber optic connections X six (6) fiber optic modules 190 in a 1-U space). Thus, the chassis 12 is capable of supporting up to one hundred forty-four (144) fiber optic connections in a 1-U space by twenty (24) simplex or twelve (12) duplex fiber optic adapters being disposed in the fiber optic modules 190. Supporting up to twenty-four (20) fiber optic connections per fiber optic module 190 equates to the chassis 12 supporting one hundred twenty (120) fiber optic connections, or sixty (60) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty (20) fiber optic connections X six (6) fiber optic modules 190 in a 1-U space). Thus, the chassis 12 is also capable of supporting up to one hundred twenty (120) fiber optic connections in a 1-U space by twenty (20) simplex or ten (10) duplex fiber optic adapters being disposed in the fiber optic modules 190.

[0052] FIG. 21 illustrates a front view of the fiber optic module 190 of FIGS. 19-20 without loaded fiber optic components 23 in the front side 202 to further illustrate the form factor of the fiber optic module 190. Front openings 208A, 208B are disposed on each side of the receiver 192 and through the front side 202 of a main body 210 of the fiber optic module 190 to receive the fiber optic components 23. The widths W1 and W2 and the heights H1 and H2 are the same as in the fiber optic module 22 illustrated in FIG. 13. Thus, in this embodiment, the width W1 of front openings 208A, 208B is designed to be at least eighty-five percent (85%) of the width W2 of the front side 202 of the main body 210 of the fiber optic module 190. The greater the percentage of the width W1 to width W2, the larger the area provided in the front openings 208A, 208B to receive fiber optic components 23 without increasing the width W2.

[0053] The width W1 of front openings 208A, 208B could each be designed to be greater than eighty-five percent (85%) of the width W2 of the front side 202 of the main body 210 of the fiber optic module 190. For example, the width
\( W_4 \) could be designed to be between ninety percent (90%) and ninety-nine percent (99%) of the width \( W_2 \). As an example, the width \( W_4 \) could be less than ninety (90) mm. As another example, the width \( W_4 \) could be less than eighty-five (85) mm or less than eighty (80) mm. For example, width \( W_4 \) may be eighty-three (83) mm and width \( W_2 \) may be eighty-five (85) mm, for a ratio of width \( W_4 \) to width \( W_2 \) of 97.6%. In this example, the front openings 208A, 208B may support twelve (12) fiber optic connections in the widths \( W_4 \) to support fiber optic connection density of at least one fiber optic connection per 7.0 mm of width \( W_4 \) of the front openings 208A, 208B. Further, each of the front openings 208A, 208B may support twelve (12) fiber optic connections in the widths \( W_4 \) to support a fiber optic connection density of at least one fiber optic connection per 9.9 mm of width \( W_4 \) of the front openings 208A, 208B.

[0054] Further as illustrated in FIG. 21, the height \( H_3 \) of front openings 208A, 208B could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 202 of the main body 210 of the fiber optic module 190. In this manner, the front openings 208A, 208B have sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 190 can be disposed in the height of a 1-U space. As an example, the height \( H_3 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_3 \) could be ten (10) mm and the height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_3 \) to height \( H_2 \) of 90.9%.

[0055] FIG. 22 illustrates another alternate fiber optic module 220 that may be provided in a fiber optic equipment tray 20' to support a higher number of fiber optic connections and connection densities and bandwidths in a 1-U space. The fiber optic equipment tray 20' in this embodiment is similar to the fiber optic equipment tray 20 previously discussed above; however, the fiber optic equipment tray 20' only contains three (3) module rail guides 32 instead of five (5) module rail guides 32. Thus, the fiber optic equipment tray 20' only supports two fiber optic modules 220 across a 1-U width space. The fiber optic module 220 does not have to provide the channel 162 or receiver 192 of the fiber optic modules 160, 190, respectively, to be disposed within the fiber optic equipment tray 20'. FIG. 23 is a right front perspective view of the fiber optic module 220 of FIG. 22. The fiber optic module 220 is designed to fit across one set of module rail guides 32 in the fiber optic equipment tray 20'. Module rails 225A, 225B, similar to the module rails 28A, 28B of the fiber optic module 22 of FIGS. 1-13, are disposed on each side 228, 230 of the fiber optic module 220 that are configured to engage with tray channels 30 in the fiber optic equipment tray 20', as illustrated in FIG. 22.

[0056] Up to twenty-four (24) fiber optic components 23 can be disposed in a front side 232 of the fiber optic module 220. In this embodiment, the fiber optic components 23 are comprised of up to twelve (12) duplex LC fiber optic adapters, which are connected to one twenty-four (24) fiber MPO fiber optic connector 234 disposed in a rear end 236 of the fiber optic module 220. Thus, with three (3) fiber optic equipment trays 20' disposed in the height of the chassis 12, a total of six (6) fiber optic modules 220 can be supported in a given 1-U space. Supporting up to twenty-four (24) fiber optic connections per fiber optic module 220 equates to the chassis 12 supporting up to one hundred forty-four (144) fiber optic connections, or seventy-two (72) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty-four (24) fiber optic connections X six (6) fiber optic modules 220 in a 1-U space). Thus, the chassis 12 is capable of supporting up to one hundred forty-four (144) fiber optic connections in a 1-U space by twenty (24) simplex or twelve (12) duplex fiber optic adapters being disposed in the fiber optic modules 220. Supporting up to twenty (20) fiber optic connections per fiber optic module 220 equates to the chassis 12 supporting one hundred twenty (120) fiber optic connections, or sixty (60) duplex channels, in a 1-U space in the chassis 12 (i.e., twenty (20) fiber optic connections X six (6) fiber optic modules 220 in a 1-U space). Thus, the chassis 12 is also capable of supporting up to one hundred twenty (120) fiber optic connections in a 1-U space by twenty (20) simplex or ten (10) duplex fiber optic adapters being disposed in the fiber optic modules 220.

[0057] FIG. 24 illustrates a front view of the fiber optic module 220 of FIGS. 22-23 without loaded fiber optic components 23 in the front side 232 to further illustrate the form factor of the fiber optic module 220 in this embodiment. A front opening 238 is through the front side 232 of a main body 240 of the fiber optic module 220 to receive the fiber optic components 23. Width \( W_4 \) of the front opening 238 is about twice the width \( W_4 \) of the front opening 98 in the fiber optic module 22 illustrated in FIG. 13. Width \( W_5 \) of the front side 232 is about one hundred eighty-eight (188) millimeters, which is slightly greater than about twice the width \( W_5 \) of the fiber optic module 22 illustrated in FIG. 13. The heights \( H_4 \) and \( H_5 \) are the same as in the fiber optic module 22 illustrated in FIG. 13. Thus, in this embodiment, the width \( W_4 \) of the front opening 238 is designed to be at least eighty-five percent (85%) of the width \( W_5 \) of the front side 232 of the main body 240 of the fiber optic module 220. The greater the percentage of the width \( W_4 \) to the width \( W_5 \), the larger the area provided in the front opening 238 to receive fiber optic components 23 without increasing the width \( W_4 \).

[0058] Width \( W_4 \) of the front opening 238 could be designed to be greater than eighty-five percent (85%) of the width \( W_5 \) of the front side 232 of the main body 240 of the fiber optic module 220. For example, the width \( W_4 \) could be designed to be between ninety percent (90%) and ninety-nine percent (99%) of the width of \( W_5 \). As an example, the width \( W_4 \) could be less than one hundred eighty (180) mm. As another example, the width \( W_4 \) could be less than one hundred seventy (170) mm or less than one hundred sixty (160) mm. For example, width \( W_4 \) may be one hundred sixty-six (166) mm and width \( W_5 \) may be 171 millimeters, for a ratio of width \( W_4 \) to width \( W_5 \) of 166/171=97%. In this example, the front opening 238 may support twenty-four (24) fiber optic connections in the width \( W_4 \) to support a fiber optic connection density of at least one fiber optic connection per 7.0 mm of width \( W_4 \) of the front opening 238. Further, the front opening...
may support twenty-four (24) fiber optic connections in the width \( W_4 \) to support a fiber optic connection density of at least one fiber optic connection per 6.9 mm of width \( W_4 \) of the front opening 238.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.

Further, as illustrated in FIG. 24, the height \( H_1 \) of the front opening 238 could be designed to be at least ninety percent (90%) of the height \( H_2 \) of the front side 232 of the main body 240 of the fiber optic module 220. In this manner, the front opening 238 has sufficient height to receive the fiber optic components 23, while three (3) fiber optic modules 220 can be disposed in the height of a 1-U space. As an example, the height \( H_1 \) could be twelve (12) mm or less or ten (10) mm or less. As an example, the height \( H_1 \) could be ten (10) mm and height \( H_2 \) could be eleven (11) mm, for a ratio of height \( H_1 \) to height \( H_2 \) of 90.9%.
<table>
<thead>
<tr>
<th>Connect or Type</th>
<th>Max Fibers per 1RU</th>
<th>Max Fibers per 4RU</th>
<th>Number of Connectors per 1 RU Space</th>
<th>Number of Connectors per 4 RU Space</th>
<th>Bandwidth per 1U using 10 Gigabit Transceivers (duplex)</th>
<th>Bandwidth per 1U using 40 Gigabit Transceivers (duplex)</th>
<th>Bandwidth per 1U using 100 Gigabit Transceivers (duplex)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplexed LC</td>
<td>144</td>
<td>576</td>
<td>72</td>
<td>288</td>
<td>1,440 Gigabits/s.</td>
<td>960 Gigabits/s.</td>
<td>1,200 Gigabits/s.</td>
</tr>
<tr>
<td>24-F MPO</td>
<td>1,152</td>
<td>4608</td>
<td>48</td>
<td>192</td>
<td>11,520 Gigabits/s.</td>
<td>7,680 Gigabits/s.</td>
<td>9,600 Gigabits/s.</td>
</tr>
</tbody>
</table>
Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which the invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. These modifications include, but are not limited to, number or type of fiber optic equipment, fiber optic module, fiber optic equipment tray, features included in the fiber optic equipment tray. Any size equipment, including but not limited to 1-U, 2-U and 4-U sizes may include some or all of the aforementioned features and fiber optic modules disclosed herein and some or all of their features. Further, the modifications are not limited to the type of fiber optic equipment tray or the means or device to support fiber optic modules installed in the fiber optic equipment trays. The fiber optic modules can include any fiber optic connection type, including but not limited to fiber optic connectors and adapters, and number of fiber optic connections, density, etc.

Further, as used herein, it is intended that the terms "fiber optic cables" and/or "optical fibers" include all types of single mode and multi-mode light waveguides, including one or more bare optical fibers, loose-tube optical fibers, tight-buffered optical fibers, ribbonized optical fibers, bend-insensitive optical fibers, or any other expedient of a medium for transmitting light signals.

Therefore, it is to be understood that the embodiments are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. It is intended that the embodiments cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

Claims

1. A fiber optic module, comprising:
   a main body defining an internal chamber defined by a front side, a rear side, and opposing first and second sides spaced apart along a longitudinal axis on either side of the internal chamber;
   a plurality of optical fibers disposed in the internal chamber;
   a front opening disposed along a longitudinal axis in the front side;
   a first plurality of simplex or duplex fiber optic components optically connected to the plurality of optical fibers, the first plurality of simplex or duplex fiber optic components disposed through the front opening;
   at least one second fiber optic component optically connected to at least one of the plurality of optical fibers to provide optical connection between the at least one second fiber optic component and at least one of the first plurality of simplex or duplex fiber optic components;
   at least one module rail disposed on each of the first and second side of the main body and extending outwardly with respect to the internal chamber along a longitudinal axis, the module rail configured for receipt in a corresponding module guide to facilitate slideable movement of the fiber optic module;
   wherein a width of the front opening is at least eighty-five percent (85%) of the width of the front side.

2. The fiber optic module of claim 1, wherein the front opening is configured to support a fiber optic connection density of at least one fiber optic connection per 7.0 millimeters (mm) of width of the front opening.

3. The fiber optic module of claim 1 or 2, wherein the front opening is configured to support at least twelve (12) fiber optic connections; and wherein a width of the front opening is 90 mm or less.

4. The fiber optic module of one of claims 1-3 being a fiber optic module further including a plurality of fiber optic components disposed through the front opening.

5. The fiber optic module of claim 4, wherein the plurality of fiber optic components is comprised of at least a plurality of fiber optic connectors and fiber optic adapters.

6. The fiber optic module of one of claims 1-5, wherein the width of the front opening is between ninety percent (90%) and ninety-nine percent (99%) of the width of the front side.

7. The fiber optic module of one of claims 1-6, wherein a height of the front opening is at least eighty-five percent (85%) of the height of the front side, preferably least ninety-five percent (95%) of the height of the front side.

8. The fiber optic module of one of claims 1-7, wherein the plurality of fiber optic components provides at least twenty-four (24) fiber optic connections, preferably at least forty-eight (48) fiber optic connections.
9. The fiber optic module of one of claims 1-8 being a fiber optic module further comprising at least one fiber optic component disposed through the rear side of the main body.

10. The fiber optic module of one of claims 1-9 being a fiber optic module wherein the plurality of fiber optic components is comprised of single fiber, fiber optic components.

11. The fiber optic module of one of claims 1-10 being a fiber optic module further comprising a fiber optic harness disposed in the internal chamber and connected to one or more fiber optic components.

12. The fiber optic module of one of claims 1-11, further comprising at least one latch disposed on the at least one module rail, the latch configured to engage the at least one module rail.

13. The fiber optic module of one of claims 1-12 being a fiber optic module disposed in fiber optic equipment comprised from the group consisting of a fiber optic chassis and a fiber optic equipment drawer.

14. The fiber optic module of one of claims 1-13, further including a fiber guide.

15. The fiber optic module of one of claims 1-14, further comprising at least one latch, disposed on the at least one module rail, the latch configured to selectively disengage the at least one module rail with the at least one module guide, thereby enabling sliding of the at least one fiber optic module in the forward-rearward direction.
### DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication, where appropriate, of relevant passages</th>
<th>Relevant to claim</th>
<th>CLASSIFICATION OF THE APPLICATION (IPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>* abstract *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* paragraphs [0049] - [0063]; figures 1,4,5,6,8,16-18 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 1, line 30 - line 45 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 7, line 8 - column 11, line 57; figures 3-9 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* abstract *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* paragraphs [0007], [0008], [0021] - [0028]; figures 1,2 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* abstract *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* paragraphs [0039], [0044], [0058]; figures *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 10, line 4 - line 25; figure 3 *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>CN 2 849 745 Y (SHENZHEN SHIJIREN COMM APPARAT [CN]) 20 December 2006 (2006-12-20)</td>
<td>1-15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* page 4, last paragraph *</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* column 4, line 32 - line 41; figure 3 *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The present search report has been drawn up for all claims.
Annex to the European Search Report

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on 21-09-2016.

The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>EP 2198327 A2</td>
<td>23-06-2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TW 200921171 A</td>
<td>16-05-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2009097813 A1</td>
<td>16-04-2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 2009045396 A2</td>
<td>09-04-2009</td>
</tr>
<tr>
<td>US 6854894 B1</td>
<td>15-02-2005</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 2002172467 A1</td>
<td>21-11-2002</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2005165158 A</td>
<td>23-06-2005</td>
</tr>
<tr>
<td>US 5071211 A</td>
<td>10-12-1991</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>CN 2849745 Y</td>
<td>20-12-2006</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 5167001 A</td>
<td>24-11-1992</td>
<td>NONE</td>
<td></td>
</tr>
</tbody>
</table>

For more details about this annex: see Official Journal of the European Patent Office, No. 12/82.
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 61218870 B [0001]
- US 12771473 B [0002]